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NEW DESIGN IN INTERIOR ARCHITECTURE RESIDENTIAL AND COMMERCIAL BUILDINGS TO CRISIS MANAGEMENT AND INCREASE SEISMIC RESISTANCE, ACCOMMODATION DURING EARTHQUAKE

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ABSTRACT

In recent years, extensive suggestions have been made regarding retrofitting and designing structures, using various structural behavior control techniques is one of the most important achievements of researchers over many years, which has led to a reduction in seismic response and improvement of structural performance. But the proposed solutions only contribute to increasing seismic capacity and do not directly play a role in increasing the safety of the residents of the building. The used methods generally discussed about the effects of earthquakes before their occurrence, and the used criteria to effectively reduce the seismic response of the structure and generally ignored the destructive effects after breakdowns. In the current study, studing post-earthquake consequences that are controlled by psychological security indicators and the effectiveness of reducing human losses are addressed through the definition of a term called Safe Site (SS). This new term refers to a space that is structurally more resistant to other building spaces and provides easier access for residents during an earthquake to find shelter. Placement of vital components, controlling gas and electricity switching operators that can put many people at risk during the earthquake in a safe site is another advantage and excellence in the installation of this site.

KEYWORDS: Critical Management, Risk, Earthquake, Interior Architecture, Seismic Performance & Dynamic Analysis

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Original Article

INTRODUCTION

The occurrence of various breakdowns in recent earthquakes in the world has led researchers and earthquake engineers to a new direction in providing new solutions to prevent the financial damages and, in particular, casualties of the buildings residents. These solutions include strengthening the surface of the structure, adding reinforced concrete walls, using steel cross braces, seismic separation with energy loss including frictional damper, member surface retention, armored columns, reinforcement of slab-to-column joints, and so on. The objectives of the research were generally to increase the stability, resistance, and improvement of the structural components and to reduce the seismic response, but directly does not play a role in increasing the safety of the residents of the building, because it is considered in all the existing methods of retrofitting to improve the function improvement of the frame or building components. Actually, the earthquake in addition to the destruction of the structural components causes the uncoupling of these parts, i.e. ceiling, floor, wall, glass face, false ceilings and other non-attached to the frame, column, and slab, which have been reinforced in existing methods. It should

be noted that significant efforts have been made to have measures in line with post-earthquake events. In some guidelines, the effects of earthquakes after occurring in the level of building efficiency has been studies and recognized. The ATC-20 [1] regulation examines the type of structural damage that has occurred in buildings after the earthquake and its usability by defining of three elements, including green, yellow, and red indicators. Researchers such as Maffei et al. [2] by the following definitions, study the seismic probability, in which, estimate the structural performance by the dynamic analyses and drawing of fracture curves and by the help of three applied characteristics has specified the building. During earthquakes with high intensity, building residents generally have no specific executive instruction that can help them to save their lives and family members and reduce the risks of after earthquakes events and they are constantly looking for a way out of the building, which in some cases has been seen that lack of adequate time and lack of healthy communication paths have led to a lot of devastating losses. After recent earthquakes, it can be seen that only structural collapses and major damages to structural components that lead to serious structural failures in buildings are not the only factor in the loss of human lives and injuries, paying attention to the hazards of the after earthquake events can play a significant role as a significant parameter. Fire in a building caused by earthquakes can be one of the most important secondary threatening causes of the lives of residents that it is due to the loss of gas and electricity control systems or the unavailability of these operators, which can be used manually. The installation of a safe site inside the building that is structurally robust will provide easy access to residents and the placement of critical controls in this section can help to increase the residents' confidence in buildings that generally have high floors that people do not have inadequate time during the earthquake, or due to structural failures and the failure of the elevator, there is no way to save lives and other members of the family.

Conducted Research Objectives

In this study, a new term called safe site has been introduced to reach a new achievement in reducing potential hazards during and after earthquakes and securing residents of buildings. In the conducted study, a safe site inside the building is being constructed which, in terms of structural strength, has a higher seismic capacity than other areas of the building, which is a space that is embedded in each floor. In order to study this definition, the studies structure is a reinforced concrete building and a safe site is embedded inside the building. In this place, which provides quick and easy access to the inhabitants of the building, the controllers and switches of vital components of the structure have been put in place that in case of earthquake people manually prevent before the disasters caused by the explosion of electricity and gas.

General Description of the Studied Structure

The studied building is considered as a concrete moment frames with medium ductility, which is widely used in today's societies. This structure is based on high seismicity and the used soil is type 2 soil (average shear wave velocity at 30 m depth is equal to 360 to 750 m/s) with an average importance factor of 1. The building has six floors, with elevations of 3.2 m and elevation of ground floor is 4 m high, and three openings equal to 5 meters which are shown in figure (1) of the plan and section of the structure. In order to create a safe site inside the building, in this research, the ceiling of the side openings is integrated and the shear wall is used in the design of the side walls. It should be noted that the frame analysis and design are based on the criteria of ACI318R-02 and the first edition of Iran's 2800 earthquake regulations.

For the gravity loading of the frames the national regulations of the building of Iran, the sixth topic, taking into account the dead load, in addition to 20% of the live load, and for the initial seismic loading, the first edition of the standard 2800 and for the modified structures, the third edition of the standard 2800 were used. The hypotheses concerning

the properties of materials and gravity and seismic loading are given in Tables (1) and (2), respectively.

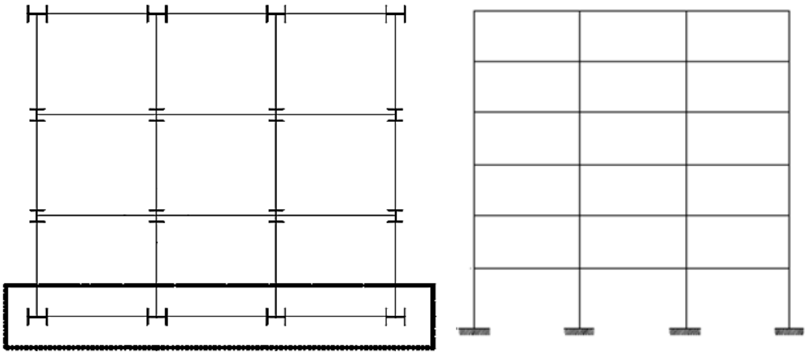

Figure 1: Plan and View of the Desired Structure

Table 1: Specifications of used Concrete and Steel Materials in Concrete Frame

f'_c(Unconfined)	24 (N/mm^2)	f_{cu}(Confined)	5.6 (N/mm^2)
ε_c(Unconfined)	0.002	ε_{cu}(Confined)	0.015
f_{cu}(Unconfined)	4.8 (N/mm^2)	E_c	24855.57 (N/mm^2)
ε_{cu}(Unconfined)	0.005	f_y	400 (N/mm^2)
f'_c(Confined)	27.579 (N/mm^2)	E_s	199947.98 (N/mm^2)
ε_c(Confined)	0.0024	Post Yield tg./Initial Elastic tg.	0.03

Table 2: Specifications of Elements used in Concrete Frame

Element/Story	B (mm)	H (mm)	Cover (mm)	Longitudinal Reinforcement	Transverse Reinforcement	Number of Bars
Columns (all floors)	400	400	50	Φ25	Φ10@100 mm	12 total
Beams (all floors)	300	400	Y direction=50 Z direction=50	Φ22	Φ10@100 mm	5 top and bottom

Analytical Frame Modeling

Moment structures were analyzed by Opensees software which is based on limited components. Because of the symmetry of the buildings in height and plan, a two-dimensional model of the desired frame is considered in the north-south direction. All moment frame columns are defined on the gripper base and all the beams and pillars in the frame are characterized by forced-based elements with a plasticity distribution along the plastic joints. In order to define the properties of steel, the steel02 material is used which is based on Giuffre- Menegotto-Pinto [3] relationships and Concrete02 concrete materials were used in introducing structural members. It is also assumed that the joints are formed at the ends of the beams and columns, and it is ignored to consider the formation of plastic joints in the joints to reduce the complexity of the structure. The reason for this is that the main contribution of the beams in the development of the ratio of floors displacement. Consideration of the reduction of hysteresis response is ignored.

The Earthquake Records used in the Analysis

By using nonlinear dynamical analysis, we can evaluate the seismic performance of structures in limit states. In selecting the used accelerograms, attention should be paid to such things as the frequency content and the matching of the soil with the soil conditions of accelerograms. On the other hand, in addition to the characteristics of each

accelerograms, the number of used accelerograms is of great importance. This means that as the number of accelerograms increases, the amount of uncertainty associated with the earthquake characteristics decreases. Shome and Cornell [4]. studies state that for medium-highlight structures, 10 to 20 records are considered to be sufficiently accurate to estimate seismic demand. Accordingly, in order to perform an incremental dynamic analysis, 15 accelerograms were used. The characteristics of these accelerograms are presented in Table (3).

Table 3: Desired accelerograms

No.	Earthquake	Station	Mw	R(Km)	PGA(g)
1	Cape Mendocino, 1992	Fortuna Blvrd	7.1	23	0.1176
2	Chalfant Valley, 1986	M.c Gee Creek Surface	6.2	36.3	0.0784
3	Coalinga, 1983	Sub	5.0	14.5	0.216
4	Hollister, 1986	Hollister Diff Array	5.4	16.9	0.101
5	San Fernando, 1971	San Onfre – So Cal Edison	6.6	122	0.011
6	Imperial Valley, 1979	El Centro Array	6.5	23.6	0.116
7	Imperial Valley, 1979	Cucapah	6.5	23.6	0.309
8	Whitter, 1989	Compton – Castlegate Street	6.0	16.9	0.332
9	Loma Prieta, 1989	Oyote Lake Dam Doanst	6.9	28.2	0.16
10	San Fernando, 1971	Wittier Narrows Dam	6.6	16	0.107
11	Loma Prieta, 1989	Anderson	6.9	21.4	0.244
12	Mt Lewis, 1986	Halls Valley	5.6	15.5	0.159
13	Northridge, 1994	LA Saturn Street	6.7	30	0.474
14	Loma Prieta, 1989	14 WAHO	6.9	16.9	0.37
15	Superstition, 1987	Wildlife Liquefaction Array	6.7	24.4	0.181

Nonlinear Analysis

Seismic response results of incremental dynamic analysis: Here, cognitive uncertainties are neglected in comparison with the inherent uncertainties caused by record to records changes. In order to study the effect of inherent variability in the earthquake in the analysis of the seismic response of the structure, an incremental dynamic analysis method has been developed. In this method, in order to consider the lack of precision in seismic prediction, an earthquake record is scaled up to cover a wide range of seismic intensity. In this analysis, the seismic response for the main and improved buildings is measured with average analyzes, the results are shown in the following figures. The results of the Open sees process have been recorded. To draw these curves, each record is scaled from 0.05Sa (T1.0.05) to Sa (T1.0.05), equivalent to 0.1 drift.) [5].

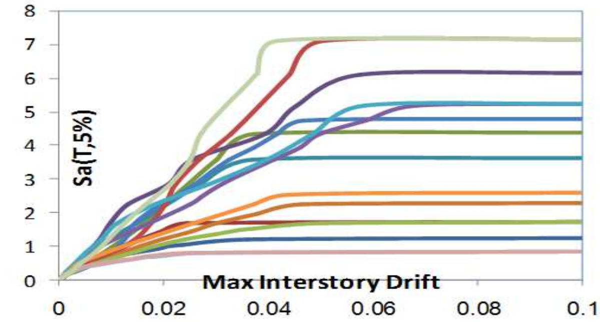

Figure 2: IDA Analysis Results of Moment Frame without Rehabilitation

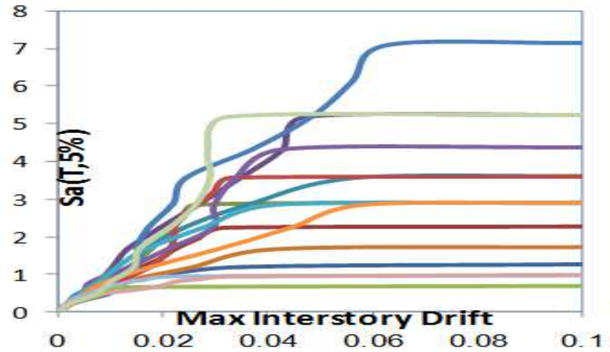

Figure 3: IDA Analysis Results of moment Frames with Shear Wall and Monolith Floor

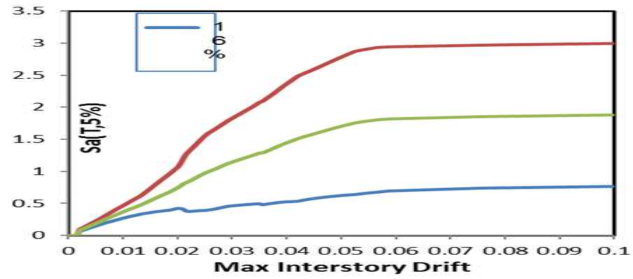

Figure 4: IDA Summarized Graphs with Regard to Frames without Rehabilitation

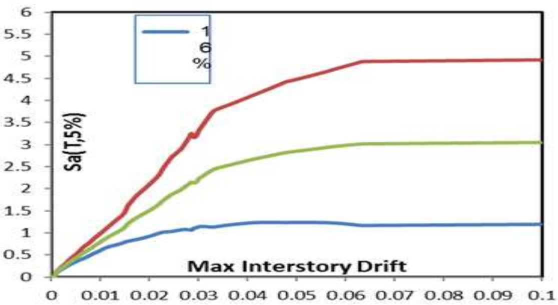

Figure 5: IDA Summarized Graphs of the Frame with Monolith Floor and Shear Walls

Estimates of Probabilities Corresponding to the Occurrence of Limit States

In order to extract the probability of occurrence of limit states from the IDA analysis outputs, conventional charts are used for fragility curves.) [6]. To plot these diagrams, the IM seismic intensity corresponds to the occurrence of the desired limit states for all records is categorized in descending order. By using arranged values, the probability of occurrence of limit states in a structure is computed for values smaller or equal to a desired IM value, which is a log-normal distribution function, and its graph is plotted against the value of IM. By using this graph, it can be said that for each IM level, the probability of occurrence of a limit state, what its amount is if IM value is limited to the desired level. Considering two limit states of its collapse threshold (CP) and immediate occupancy (IO), comparing the fracture curves of structures related to structures are presented in the following forms [7].

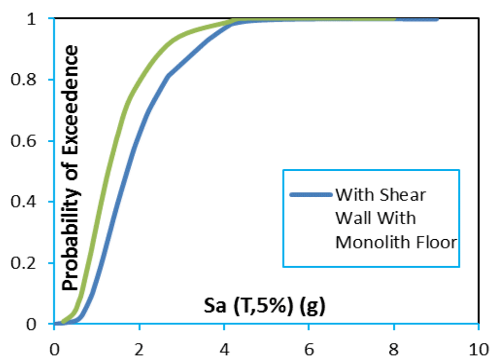

Figure 6: Comparison of IO Operational Level of Fragility Curves for both Frames

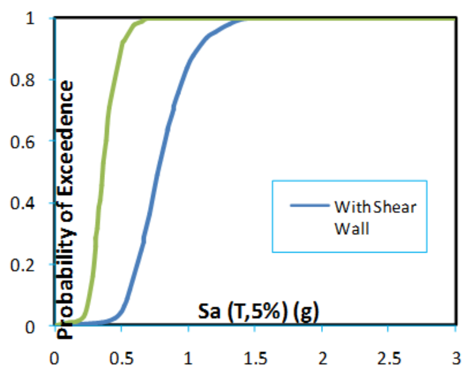

Figure 7: Comparison of CP Operational Level of Fragility Curves for both Frames

Calculating the Average Annual Occurrence Rate of Limit Events

Numerical Solution Method

Given that the DM represents the seismic demand and the IM represents of the size of the intensity, we will have:

$$\lambda_{DM(y)} = \int P_{DM|IM(y|x)} \cdot |d\lambda IM(x)|$$

In this regard, $\lambda_{DM(y)}$, [8]. is the average annual rate of DM from the value of y, and $P_{DM|IM(y|x)}$ that is extracted from the results of nonlinear dynamic analysis indicates the probability of an encroachment of the DM from the

value of y, provided that IM is equal to x. It should be noted that this expression includes the uncertainty of a structural requirement on a particular level of intensity. dλIM(X) is differential seismic hazard function in terms of IM, which is derived from the calculation of the risk analysis. Given the structural data and the above relationship, we will:

$$\lambda_{LS} = \int F_{LS|DM(y)} . |d\lambda IM(y)|$$

In this equation, dλIM(y) represents the differential of the seismic demand risk relative to DM (calculated in y), the expression $F_{LS|DM(y)}$ has the probability of exceeding the limit state provided that DM is equal to y.

By expanding the above relation, the average annual rate of occurrence of the limit state is obtained based on the following equation:

$$\lambda_{LS} = \int_{IM=0}^{IM=\infty} F(IMc|IM) . \left|\frac{d\lambda_{IM}}{dIM}\right| dIM$$

In this regard, the quantity inside the absolute value, the IM, and $F(IMc|IM)$ risk gradient is the cumulative distribution function of the capability-related capacity in terms of the IM variable. Here, this function is the same as the fracture function. In order to calculate the amount inside the absolute value, it is necessary to analyze the seismic hazard of the site of the structure. Seismic hazard analysis provides a uniformly simplified risk spectrum with a return period of 475 years and 2475 years. Then, with regard to the period of the structure, we can determine the spectral accelerations corresponding to both return periods and determine the parameters K_0 and t according to the following equation.

$$\lambda_{Sa} = K_0(Sa^{-t})$$

According to the above, in this research, regional seismic hazard analysis with a radius of 150 km from the center of Tehran has been used between geographical coordinates (49.80E-53.10E) and (34.35 N-37.10N) [9]. Simplified uniform hazard spectra with a return period of 475 years and 2,475 years for this region are presented in the following figure. The parameters K_0 and t are given in Table (4). The uniform hazard curves obtained for both frames are shown in Figure 9.

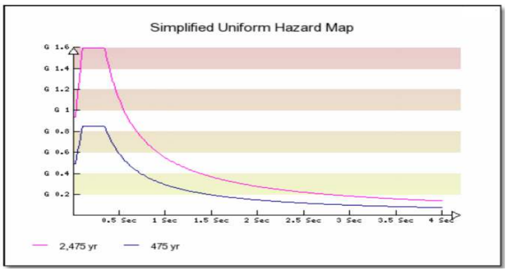

Figure 8: Simplified Uniform Hazard Spectrum [8]

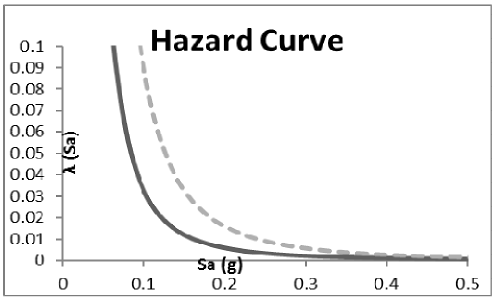

Figure 9: A Comparison of the Uniform Hazard Curves obtained for all Three Frames

Table 4: Seismic hazard parameters

Parameter	T=0.994	T=0.6
K_0	9.92e-5	0.000294
t	-2.53722	-2.71908

Closed Form Method

Cornell and Jalayer [10] used a closed-form solution method to estimate the average annual frequency of its collapse using the following equation. In this equation, k is the slope of the hazard curve, and η_C and β_{RC} are respectively the mean and standard deviation of the fracture curve in normal log environments.

$$\eta_c = \exp(\text{mean}(\ln sa))$$

$$\lambda_c = [\lambda_{sa}(\eta_c)]\left[\exp(\frac{1}{2}k^2\beta_{Rc}{}^2)\right]$$

Calculating MAF of Limit States

By using the values obtained in the fracture curves, and by using the numerical integral method and the closed form method, the average annual rate of occurrence in two levels of collapse threshold and continuous service is according to Table (5). These values are very useful as quantifies that reflect the overall probabilistic capacity of structures, relying on the uncertainties caused by the earthquake. These values can be used as a criterion for assessing the structural reliability of a building in comparison with other structures.

Table 5: Average Rate of Occurrence of Limit Cases

Types of Modes	Frame without Shear Wall		Frame with Shear Wall and Monolith Floor	
	Io	CP	IO	CP
MAF Occurrence (numerical solution)	0.00143	0.00012	0.000568	0.000164
Closed form solution	0.00163	0.000132	0.000654	0.000167

RESULTS

As it was mentioned in the introduction, most of the seismic rehabilitation or seismic improvement methods are based on the reinforcement of structural components, while during an earthquake in the case of non-structural and non-reinforced collapse, due to lack of sufficient time, the exit action will cause casualties. In this research, for the first

time, structural safe site has been constructed in order to enhance the psychological mood of the inhabitants by using the integrated ceiling, floor, and wall while being resistant during the earthquake. As residents of this building, while finding out the safe site in a part of their residential building during an earthquake, are located in it and use a guide on how to deploy in this safe place and how to cut off all the controllers and terminals of gas, water and electricity, as well as using first aid services. Also, in this study, dynamic and nonlinear analysis was studied and the way of increasing the structural strength of the building and reducing its seismic response are presented in the diagrams. In the future of management and regulations, the place controllers and switches of gas and electricity located and the way of residents' lodgment in future research will be discussed.

التصميم الجديد في العمارة الداخلية للمباني السكنية والتجارية بهدف إدارة الأزمة و زيادة المقاومة الزلزالية، الاستقرار عند الزلزال

الملخص

وفي السنوات الأخيرة، قدمت اقتراحات واسعة بشأن إعادة تصميم الهياكل و تصميمها. استخدام الأساليب المختلفة لمراقبة السلوك البناء (الاحداث) هو من أهم إنجازات الباحثين في سنوات طويلة، و قد أدّت هذه الإنجازات إلى الحد من الاستجابة الزلزالية و تحسين الأداء الهيكلي. ولكن الحلول المقترحة تؤدي فقط إلى زيادة القدرة الزلزالية ولا تلعب دورا مباشرا في زيادة سلامة سكان المبنى. و تنوقشت الطرق المستخدمة عموما حول آثار الزلازل قبل حدوثها و قد فعلت مؤثرا المعاييرُ المستخدمة للحد من الاستجابة الزلزالية للهيكل و تتجاهل الآثار المدمرة بعد الفشل عموما. فى هذا المقال تدرس آثارُ ما بعد الزلزال التي قد تحكمت مؤشرات الأمن البشرى عليها و مقدارُ التأثير فى تخفيض الخسائر الروحية باستعانة وصف مفردة تسمّى المكان الأمن. يطلق هذا المصطلح الجديد على فضاء تمتلک قدرة عليا تجاه المساحات الأخرى للبناء و توفر المأوى سهولة الوصول للمقيمين خلال الزلزال. وضع المكونات الحيوية للسيطرة على مشغلي الغاز والكهرباء التى يمكن أن تعتبر خطرا جدا على الناس في المبنى خلال الزلزال فى الفضاء الأمن يعتبر الميزات و الإيجابيات الأخرى المتوفرة لهذا المكان الأمن.

الكلمات الرئيسية: إدارة الأزمة، الخطر، العمارة الداخلية، الزلزال، الأداء الزلزالي، المساحة الأمنة، الإطار، التحليل الديناميكي

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